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Tammy Veenstra

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Abstract

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An Inference Based Approach

by

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Table of Contents

List of Tables

Abstract

The Common Core State Standards have provided schools with a new set of required objectives. Specifically in the area of statistics and probability, seventh grade math teachers have new objectives they are required to teach, but they do not necessarily have the required knowledge or curriculum to meet the standards. The Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report and the college introductory level statistics curriculum *Introduction to Statistical Investigations* were used as resources and revised for the seventh grade level to teach the standards for seventh grade statistics during a three-week statistics and probability unit. Results of observations and written assessments indicated the inference-based approach effectively taught the students the required standards, with post-test scores averaging 12.75% better than pre-test scores. Revisions of the unit are ongoing in order to promote an even higher engagement level of the students and provide more real-life examples for both a seventh grade and full K-12 statistics education program.

In 2010, the United States Department of Education adopted the Common Core State Standards in order to “provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what to do to help them" (National Governors’ Association, 2010). These standards for math and language arts were “designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers” (National Governors’ Association, 2010). Specifically in the area of mathematics, in comparison to other countries, it became clear that the United States needed to make significant changes in order to strengthen a relatively weak program. “[T]he mathematics program in the United States must become substantially more focused and coherent in order to improve mathematics achievement in this country” (National Governors’ Association, 2010). The Common Core State Mathematical Standards have outlined eight mathematical practices all United States math students should adhere to. (See Appendix A.) These practices are to be the ways in which students engage in the mathematical content standards as also described in the Common Core State Mathematical Standards. The focus of this study specifically addressed the standards outlined for seventh grade students in the domain of Statistics and Probability as also listed in Appendix A and sought to determine the effectiveness of a curriculum focusing on a randomization approach to statistical inference in promoting student engagement and academic achievement.

Statistical information is presented to students every day whether found on the news, in weather forecasts, in movie reviews, or in recaps of sporting events. Students need to have an understanding of this data. The Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report describes the importance of statistical literacy: “Our lives are governed by numbers. Every high school graduate should be able to use sound statistical reasoning to intelligently cope with the requirements of citizenship, employment, and family to be prepared for a healthy, happy, and productive life" (Franklin, Kader, Mewborn, Moreno, Peck, Perry, & Scheaffer, 2007).

Problem

At first look, teachers may greatly appreciate the efforts of the Common Core State Standards for Mathematics. With a goal of clarity and specificity and an attempt to address the problem of a curriculum that is "a mile wide and an inch deep," teachers should find these standards as a tool that will provide a well-defined map for guiding instruction. However, along with the CCSSM come new challenges. Teachers now face a long list of objectives that have never existed before in the curriculum. The standards for statistics and probability are focused and clear, but new to the seventh grade level. Of the list of eight basic standards for seventh grade in the domain of statistics and probability, only three of those standards were previously addressed but not with the same level of focus as prescribed by the eight mathematical practices outlined in the Common Core State Standards for Mathematics. The objectives are new for middle school math teachers, and there are few curriculum materials that support instruction.

Research Questions

The adoption of the Common Core State Standards for Mathematics is necessary. The inclusion of a strong focus on statistics and probability is of great benefit to the students for thriving in today's society and in their future careers. However, adopting these standards comes with challenges for the curriculum, the instructors, and the learners. Because adopting these standards is not only required, but also beneficial, mathematics teachers must take the time to examine the standards and prepare meaningful lessons for their students. This study looked specifically at the standards for statistics and probability for seventh grade students and the methods employed by a randomization-based introductory statistics course. The questions examined in understanding the new standards and implementing them in a seventh grade classroom setting included:

1. How does a statistics curriculum adapted from an undergraduate statistics text focusing on a randomization approach to statistical inference promote student engagement in a seventh grade math class at a small Christian school?
2. What level of improvement in understanding statistical inference and the Common Core State Standards for Mathematics in the area of probability and statistics is observed and assessed?

Definitions

For the purpose of this study, the following definitions will clarify the meaning of the terms used throughout. Unless otherwise indicated, the definitions are the researcher's own.

Common Core State Standards – The Common Core State Standards are a list of standards that provide a consistent, clear understanding of what students are expected to learn. They are "designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers" (National Governors' Association, 2010).

Curriculum – For the purpose of this study, when stating curriculum, the researcher is referring to the textbook, activities, and materials that students use to learn objectives set for each course.

Pedagogy – Pedagogy refers to the art or instructional methods of teaching.

Probability – "The probability of a random event occurring is the long-run proportion (or relative frequency) of times that the event would occur if the random process were repeated over and over under identical conditions. You can approximate a probability by simulating the process many times. Simulation leads to an empirical estimate of the probability, which is the proportion of times that the event occurs in the simulated repetitions of the random process" (Tintle, Chance, Cobb, Rossman, Roy, Swanson & VanderStoep, 2013).

Simulation – "A simulation is an artificial version of a random process. It is used to study the long-term properties of the process" (Tintle et al., 2013).

Statistics – Statistics can refer to both the discipline and that data collected. As a discipline, or subject matter, statistics "guides us in collecting, exploring, and drawing conclusions from data" (Tintle et al., 2013). When referring to collected data, statistics are "values measured or categories recorded on individual entities of interest" (2013).

Statistical inference – Statistical inference refers to the process by which one "draws conclusions beyond the sample data to a larger population or process" (Tintle et al., 2013).

Statistical Literacy – Statistical literacy is the ability to read and understand statistics.

Variability – Variability refers to "fluctuations in data" (Tintle et al., 2013). Variability needs to be considered, as results from random samples will most likely vary from sample to sample.

Literature Review

There are many challenges to adopting the Common Core State Standards for Mathematics, specifically in the domain of Statistics and Probability. First of all, there is a significant increase in the number of statistics standards that seventh grade math teachers are to teach. "CCSSM places a large amount of statistics content in the middle grades, thus charging middle school teachers with the responsibility of delivering a major portion of students' statistics education" (Groth & Bargagliotti, 2012).

With the increase of new standards specific to seventh grade math, the result has been a "flurry of activity as teachers brainstorm about how to design curriculum and pedagogy that embody the standards" (Gewertz, 2012). Textbooks have not been written currently that address the common core standards. "[T]extbook publishers are scrambling to catch up with the common standards and few, if any, materials that truly align are available" (Robelen, 2012).

The National Governors' Association recognizes the limits of the standards as well. "Standards by themselves cannot raise achievement. Standards don't stay up late at night working on lesson plans, or stay after school making sure every student learns – it's teachers who do that" (National Governors' Association, 2010). Education leaders such as the state board and local superintendents and principals must see to it that the standards are implemented. Publishers also play a crucial role in providing textbooks and materials needed to meet the higher standards (2010).

The curriculum is lacking in alignment. Publishers need to work on that. In the meantime, the teachers still have a responsibility to teach the standards. These teachers, similar to the curriculum, are lacking in their ability to "truly align" their teaching with the standards. "The lack of pedagogical recommendations in CCSSM means that teachers and schools are responsible for seeking, testing, and refining teaching approaches" (Groth & Bargagliotti, 2012). With most of the statistics objectives in the CCSSM being new to middle school curriculum, the responsibility to align becomes even more challenging (2012). Teachers have not been adequately prepared to teach these new standards. Their inability to teach these topics effectively may well have less to do with their motivation or how hard they work and more to do with the fact that they are not adequately prepared to teach these subjects" (Schmidt, 2012).

Another challenge in teaching statistics, specifically the new seventh grade statistics and probability standards, is that it is difficult to quickly provide illustrations or examples to engage the students or help the students develop a deeper understanding of the concept. With most of the previous seventh grade standards, it was rather effortless to present students with an illustration of the concept. For example in teaching percentages, a teacher can readily brainstorm a shopping illustration that seventh grade students are familiar with. Statistics illustrations are much more challenging. The context of the statistics problem is often complex, requiring real-life data and descriptions of the scenario. Cobb and Moore (1997) elaborated on the profound implications this has for teaching:

> To teach statistics well, it is not enough to understand the mathematical theory; it is not even enough to understand also the additional, non-mathematical theory of statistics. One must, like a teacher of literature, have a ready supply of real illustrations, and know how to use them to involve students in the development of their critical judgment. In mathematics, where applied context is so much less important, improvised examples often work well. … In statistics, however, improvised examples don't work, because they don't provide authentic interplay between pattern and context. (p. 803)

Finally, teachers are challenged with having to teach new concepts, concepts that they may not be familiar with or even understand. These concepts were previously taught at higher grade levels. While they may have read these standards and are willing to teach them, teachers may not fully understand the complexity and challenges that will arise when trying to teach students a genuine understanding of these statistical standards (Gewertz, 2012).

Challenging the curriculum and the teachers, these new mathematical standards in statistics and probability also challenge the seventh grade students. "The Common Core State

Standards are rigorous, focused, and demanding – especially at the middle school level. This is all for the benefit of American students, but the lack of attention to implementation could prove disastrous" (Schmidt, 2012). If teachers have not properly planned the implementation of the standards, it is the students who suffer.

The transition to the new standards could also prove to be challenging for middle school students. "[I]t's not simply a matter of flipping a switch to have instruction at all grade levels reflect the new standards. After all, a lot of math content builds on prior learning" (Robelen, 2012). The students are not going to be able to fully grasp some of the statistics and probability standards because they have not been exposed to the standards that will be taught in prior grades but have not been taught before the adoption of the Common Core State Standards for Mathematics. Some schools have opted to introduce the standards incrementally to aid in building teacher and student capacity (Robelen, 2012).

The GAISE Report (Guidelines for Assessment and Instruction in Statistics Education Report) endorsed by the American Statistics Association provides a framework that describes the cognitive development levels of students and suggests the steps students should take in studying statistics. The levels labeled as A, B, and C are thoroughly described, including the students' cognitive abilities, the role of the teacher, and suggested activities for each level. At the beginning level, Level A, students have a beginning awareness of questions that are statistical in nature. At Level B, the students have an increased ability to identify statistical questions, and at Level C, students are able to full recognize and pose their own statistical questions. In the seventh grade, students should be at Level B, but without previous experience with statistics, they may begin at Level A (Franklin et al., 2007).

At each of the cognitive levels, students follow an investigative process involving four components: 1) Formulate Questions 2) Collect Data 3) Analyze Data and 4) Interpret Results. The first component, formulating questions, involves clarifying the problem at hand and formulating questions that can be answered with data. The second component, collecting data, involves designing a plan for collecting appropriate data and employing the plan to collect the data. Next, in analyzing data, the students select appropriate graphical and numerical methods and use these methods to analyze the data. Finally, the fourth component, interpret results, involves interpreting the analysis and relating the interpretation to the original question (Franklin et al., 2007).

While the Common Core State Standards for Mathematics include ambitious statistics and probability standards, the GAISE report does serve as a road map, helping teachers implement the standards. The Common Core State Standards lack pedagogical approaches, meaningful statistics connections, and developmental trajectories for students' statistical learning. However, the GAISE report offers this neglected support. Hand in hand, with the GAISE report alongside the Common Core State Standards, curriculum can be written, pedagogy can be explored, and the students can be successfully taught the statistic and probability objectives of the Common Core. The process of statistical investigation outlined in the GAISE prepares students for realistic statistical thinking in that,

> [r]ather than producing graphical displays and summary statistics for their own sake, students' work can be closer to the heart of a statisticians' work when these activities are performed in the context of investigations. As students are encouraged to delve into the process of statistical investigation, they can begin to adopt the same modes of inquiry and

> patterns of thinking used to address authentic problems in practice. (Groth & Bargargliotti, 2012, p. 41)

Cobb (2007) also recognized the challenges with both the statistics curriculum and pedagogy and proposed major changes to the traditional statistics course:

> We need a new curriculum, centered not on the normal distribution but on the logic of inference…We need to throw away the old notion that the normal approximation to a sampling distribution belongs at the center of our curriculum, and create a new curriculum whose center is at the core logic of inference. (p. 11).

Traditional statistics curriculums have focused on following algorithms, step-by-step directions, through specific formulas to calculate the statistically likelihood of events and significance. However, in today's society, computers can make those calculations. What is needed is a curriculum that will train students to think, to analyze, to question, to infer, to develop statistical reasoning and core logic. By following the process of the three R's - randomize, repeat, reject – students can compare the results of real data to randomized results. Using simulations, they are able to repeat the process several times to determine what typical results are. Once the typical random result is found, the students are able to infer the significance of the real result. Was it typical? Was it significant? If the result is the same as a random result, the students can reject the significance of the presented statistic. However, most traditional curriculums overlook statistical inference and reasoning to focus on formulas and calculations. In order to improve statistics instruction, schools must demand a new curriculum that is readily accessible for teachers to implement and inspire "a new generation of adventurous teachers, willing to lead their students down roads less trammeled" (Cobb, 2007).

Before leading these students down "roads less trammeled", it is imperative that teachers have a deep understanding of who these students are. Seventh grade students are usually twelve and thirteen years old. "Each person is first and foremost a creation of God" (Fennema, 2005). Students' primary identities should come from their relationship with God. Created to glorify God, everything they do should be for Him and dependent on Him. Without God, man would not have the predictability that comes in statistics and probability. Without a lawful and providential God, predictable realties would not exist. The students studying statistics and probability can trust predictability only as far as God has ordained (Fennema, 2005).

Being created by God, for His glory, all students are image-bearers of their Creator. Bearing His image, they are active and purposeful. They enjoy being active and trying to gain some sense of control in the world. They are rational, able to perceive, understand, conceptualize, and evaluate intellectually what is around them. This attribute will serve them well in studying statistics. Other attributes include being creative, having a moral understanding of what is right and wrong, being faithful, free and responsible. The students are able to make choices and judgments, potentially based on the statistics they study. Able to exercise dominion, the students will have a sense of control over what is around them. Again, the knowledge they gain in statistics may help guide them in their stewardship roles. Finally, the students are social and loving. They were created to love and be loved. This will play into their abilities to work with other students and teachers in calculating statistics, probabilities, and using that data to help others. Hopefully, the students will use their knowledge of statistics and probability to serve their Creator while working with other students and statisticians (Graham, 2003).

As twelve- and thirteen-year-old adolescents, the students in the mathematics classroom have the ability to remember several details. They also are able to understand symbolism, metaphors, and analogies (Feinstein, 2009). "The adolescent is ready to hypothesize, create abstractly, and comprehend complex math theorems" (2009). They can deduct, analyze, and logically reason. It is also possible for adolescents to make reflective decisions, perhaps based on the results of their statistical investigations (2009). Seventh grade students are at the stage Piaget calls the formal operational stage. This is the last of Piaget's stages of cognitive development. In this stage, "the child becomes able to reason not only about tangible objects and events, but also about hypothetical or abstract ones" (Seifert & Sutton, 2009). Requiring relatively few "props" to help solve problems, seventh grade students can operate with forms and representations. They can manipulate ideas that vary in several ways at once, entirely in their minds (Seifert & Sutton, 2009). The literature seems to suggest that seventh grade students are capable of achieving the statistics and probability standards as presented in the Common Core.

Based on who the students are cognitively and spiritually, what should teachers require from them or desire them to be as statisticians? Do teachers desire students who follow step-by-step instructions, memorize formulas, and produce results with little understanding? Or rather, do they desire students who reflect, analyze, and infer meaning when working with statistics? Placing inference at the heart of the statistics and probability math course is imperative. As Image-bearers and stewards of God's creation, students should be taught to think, not simply compute, to reason and infer, not simply produce ratios and percentages. Calculating, computing, and producing is necessary, but as a means, not an end; as a process, not the product.

"Recommendations of GAISE involve the use of more active learning - less lecturing, more projects, lab exercises, group problem solving and discussion; use of real data; use of technology; and an approach that emphasizes conceptual understanding, statistical literacy, and statistical thinking" (Tintle, Topliff, VanderStoep, Holmes, & Swanson, 2012). Utilizing simulation and randomization tests to motivate the logic of statistical inference, Tintle et al. (2013) have developed a full-length introductory statistics text for undergraduate college students, titled *Introduction to Statistical Investigations.* While this text is aimed at college students, the objectives covered require an understanding of the objectives taught in seventh grade. Rather than memorizing procedures and step-by-step directions with little comprehension, Tintle believes that students should spend time exploring the concepts and contexts of the statistical scenarios and in return gain genuine understanding. The writers took an active-learning approach and implemented the GAISE pedagogy while completely re-ordering, re-emphasizing, and adding and subtracting content from the consensus curriculum (Tintle, VanderStoep, Holmes, Quisenberry, & Swanson, 2011).

Evaluating the learning gains of the curriculum showed significant gains in student learning compared to the consensus curriculum likely due to a combination of improved pedagogy and content (Tintle et al., 2012). The CAOS test (Comprehensive Assessment of Outcomes in Statistics) was given to students before and after the full randomized-based introductory statistics course and the scores of those students were compared with the scores of both a nationally representative sample of undergraduate students and a sample of students from Hope College in Holland, Michigan, who had taken the traditional introductory statistics course two years previously. The national representative sample had an average pre-test score of 44.9% compared with a post-test score of 54.0%. The sample from the traditional course at Hope College had an average score of 48.4% on the pretest, followed by a post-test score of 57.2%, and the sample from the new course, using a randomized-based introductory statistics course curriculum, had a pre-test average of 44.7% followed by a post-test average of 55.7%. A 100% represents achieving all of the content learning goals for the course. The national sample improved 9.1%, the traditional sample at Hope College improved 8.9%, and the sample using the new curriculum improved 11%. When looking at the results by topic, students who had used the new curriculum better understood concepts of significance, design, and simulation (Tintle et al., 2011).

While this randomization-based statistics curriculum has shown improvement in undergraduate students abilities to understand statistics concepts, what does it offer a seventh grade math curriculum? Tintle et al. (2011) explained how a randomized-based curriculum addresses the major critiques of a traditional curriculum:

> First, it focuses students' attention towards the logic of inference instead of focusing their attention on asymptotic results which are disconnected from real data analysis and inference. Secondly, it gives students exposure to a modern, computationally intensive technique which is rapidly growing in popularity. Furthermore, in this curriculum, we have addressed other issues in content suggested by CAOS (de-emphasizing descriptive statistics) as well as significant changes to pedagogy as suggested by GAISE (active learning approaches). (p. 14)

These are the same significant changes as required by the Common Core State Standards for Mathematical Practice.

The *Introduction to Statistical Investigations* text emphasizes the core logic of statistical inference by using randomization tests. It uses real-life data and encourages group work and discussion. By its design, it promotes a deeper and more intuitive understanding of the statistical concepts. Placing inference at the center of classroom instruction and using the examples and approach of Tintle's text, the Common Core State Standards for Statistics and Probability at the seventh grade level can be taught. Using the following methods, the researcher sought out to determine if this curriculum and pedagogy would prove to be equally effective with the seventh grade learner.

Methods

The Common Core State Standards for Mathematics in the domain of Statistics and Probability must be adopted in all math classrooms in the United States, including specifically the seventh grade math class. The researcher used the standards along with the guidelines presented in the GAISE report, the approach of focusing on inference as described by George W. Cobb and developed by Tintle in his text *Introduction to Statistical Investigations*, and examples from Tintle's text to develop and teach a three-week unit on probability and statistics in the seventh grade math classroom.

Participants

The seventh grade and eighth grade math classes at a small Christian school in eastern Iowa were the participants in this study, along with their teacher, the researcher, in the fall of 2013. The classes consisted of a total of twenty-five students. These students differed widely in their God-given mathematical abilities.

Materials

Using the Common Core State Standards for Mathematics, the GAISE report, Tintle's *Introduction to Statistical Investigations*, and the CAOS, a 40-question, online multiple choice test that assesses students' conceptual understanding of topics taught in a traditional introductory statistics course, the researcher developed a pre-test (Appendix B), a three-week unit on statistics and probability, and a post-test (Appendix B), to attempt to teach the standards as presented in the Common Core to the seventh and eighth grade math classes at a small Christian school in eastern Iowa in the fall of 2013. The lesson plans were developed by the researcher, incorporating the eight practices for math students as outlined in the Common Core, the eight standards for seventh graders in the Common Core State Standards, and the framework from the GAISE report, using Tintle's *Introduction to Statistical Investigations* and revising it for the unique cognitive development and standard requirements of seventh grade students.

Procedure

The researcher began by writing a three-week unit for seventh grade students on the topic of statistics and probability, incorporating the eight practices for math students as outlined in the Common Core, the eight standards for seventh graders in the Common Core State Standards, and the framework from the GAISE report, Tintle's *Introduction to Statistical Investigations* and revising it for the unique cognitive development and standard requirements of seventh grade students. The participants in this study, the seventh and eighth grade math classes, first took a pre-test developed by the researcher to determine any prior knowledge the students had of the standards. This pre-test used questions mainly found in the CAOS test to assess each of the objectives presented in the Common Core for Statistics and Probability. Next, the researcher taught the three-week unit. Following instruction, the students were assessed with the post-test in Appendix B. The level of engagement throughout the three week unit, along with the difference in ability seen from the pre-test to the post-test aided the researcher in determining the effectiveness of the unit.

Results

To measure the effectiveness of the randomization-based curriculum focused on inference-based learning and hands-on activities, students were given both a pre- and post-test developed based on the CAOS test.

Data Analysis

The level of improvement from the initial pre-test to the final post-test has been recorded in the following table.

Table 1. Pre-test and post-test results

<table>
<tr><th>Standard</th><th>Item # on Test</th><th colspan="6">% of Class Correct Pre-Test</th><th colspan="6">% of Class Correct Post-Test</th><th colspan="6">Difference from Pre-Post Test %</th></tr>
<tr><td>7.SP.A.1</td><td>16,17</td><td colspan="3">80%</td><td colspan="3">84%</td><td colspan="3">88%</td><td colspan="3">96%</td><td colspan="3">8%</td><td colspan="3">12%</td></tr>
<tr><td>7.SP.A.2</td><td>8,10,14</td><td colspan="2">24%</td><td colspan="2">20%</td><td colspan="2">60%</td><td colspan="2">32%</td><td colspan="2">44%</td><td colspan="2">84%</td><td colspan="2">8%</td><td colspan="2">24%</td><td colspan="2">24%</td></tr>
<tr><td>7.SP.B.3</td><td>11,12,13</td><td colspan="2">52%</td><td colspan="2">48%</td><td colspan="2">48%</td><td colspan="2">84%</td><td colspan="2">60%</td><td colspan="2">56%</td><td colspan="2">32%</td><td colspan="2">12%</td><td colspan="2">8%</td></tr>
<tr><td>7.SP.B.4</td><td>7,9</td><td colspan="3">8%</td><td colspan="3">64%</td><td colspan="3">16%</td><td colspan="3">60%</td><td colspan="3">8%</td><td colspan="3">-4%</td></tr>
<tr><td>7.SP.C.5</td><td>1</td><td colspan="6">92%</td><td colspan="6">100%</td><td colspan="6">8%</td></tr>
<tr><td>7.SP.C.6</td><td>2</td><td colspan="6">52%</td><td colspan="6">56%</td><td colspan="6">4%</td></tr>
<tr><td>7.SP.C.7</td><td>3</td><td colspan="6">84%</td><td colspan="6">92%</td><td colspan="6">8%</td></tr>
<tr><td>7.SP.C.8</td><td>6,5,15</td><td colspan="2">64%</td><td colspan="2">64%</td><td colspan="2">40%</td><td colspan="2">68%</td><td colspan="2">76%</td><td colspan="2">76%</td><td colspan="2">4%</td><td colspan="2">12%</td><td colspan="2">36%</td></tr>
</table>

	Average Score Pre-Test	**Average Score Post-Test**	**Difference**
Fall 2013	8.8/16 = 55%	10.84/16 = 67.75%	12.75%

Improvement was shown for every test item but one, resulting in an overall average improvement of 12.75% from the pre-test to the post-test. This is very similar to the results found for introductory statistics courses using the *Introduction to Statistical Investigations* curriculum. Items from the post-test showing the greatest improvement suggest students improved most in the standards 7.SP.2, 7.SP.3, and 7.SP.8. These standards focus on drawing inferences about a population, assessing variability in two data sets, and finding compound probabilities using simulations. Each of these standards is a key component of the *Introduction to Statistical Investigations* curriculum.

Findings

The beginning of the unit focused on the basics of probability. Students were taught definitions of probability and how to calculate simple and compound probabilities. They were introduced to dot plots, simulations, and hands-on activities involving coins, playing cards, and iPad activities. The researcher started each day in whole group instruction, followed by small group work, and ended with individual practice. For the first week, the students were engaged in class discussion but often showed confusion, frustration, and some boredom. The wording of the questions was confusing to students, and the teacher often had to rephrase the questions for the students or present another example. Once the students caught on to the activity, the results were very straightforward, leading to little discussion. The students were seeking immediate results and when they did not find immediate results, they quickly responded with frustration until further explanation was given.

As the focus of the curriculum shifted to real-life examples with statistical scenarios for the students to analyze using the randomized-based methods taught the first week, the engagement level of the students also increased. Once again, the teacher started with whole group instruction, followed by group work, and then an individual activity. For the whole group examples, the students were less likely to participate and offer answers to the teacher’s questions. However, in small group work, the students were very actively engaged either in offering solutions, suggestions, or offering their frustrations and questions about the material. It was observed that the students showed more patience and perseverance when working with real-life data.

Overall, the researcher found that as the students gained both knowledge and familiarity with the topic of statistics, the engagement level increased. Also, as the curriculum focus shifted from learning the tools of statistics to applying the tools to make inferences about real-life scenarios, once again the engagement level and overall interest increased. The students were more likely to share their ideas and suggestions as well as their questions in small groups as opposed to in whole group instruction and independent work time.

Discussion

Finding the curriculum and support for teaching the Common Core State Standards for Statistics and Probability at the 7^{th} grade math level lacking, the researcher incorporated the eight practices for math students as outlined in the Common Core, the framework for teaching statistics as presented by the GAISE report, Tintle's *Introduction to Statistical Investigations,* and recommendations for the unique cognitive development of seventh grade students to write and implement a three-week unit in probability and statistics. This unit took an inference-based approach to develop statistical literacy and to effectively teach the objectives as found in the Common Core for statistics and probability. The structure of each class started with whole group instruction, followed by group work, and lastly, individual practice. Recommendations of using real-life data, group work, discussion, hands-on activities, and technology components were implemented in the three-week unit with the goal of promoting a deeper and more intuitive understanding of the statistical concepts. Based on previous research, it was evident that the need exists for a curriculum that will train students to think, to analyze, to question, to infer, and to develop statistical reasoning and core logic.

The unit took a slow start. The students were hesitant to participate in the hands-on activities. Results that were not immediate were found to be frustrating. Students had a difficult time thinking beyond the scope of giving simply “the right answer.” Having been trained to use a basic algorithm to produce a specific result, the concept of statistical literacy was very foreign to the students.

The researcher had pre-determined that the students would start by learning how to calculate basic probabilities using probability models of flipping coins, drawing cards from a deck, and choosing colored candies. These models were to be more hands-on and engaging for the students. However, students at the seventh grade age level, while eager to have something to actively flip or draw, struggled to make real-life connections or applications of the models. They were not engaged by the examples and found them uninteresting. It was a challenge to encourage active discussion amongst the group, and most of the students desired a quick calculation of the right answer rather than a lengthy discussion of the concepts being presented. The teacher found similar frustration. It was difficult to provide the students with rationale for the basic probability models without real-life examples.

When the focus of the curriculum shifted from the tools of probability to applying chance models to determine statistical significance of real-life scenarios, the students’ engagement levels increased. This is not surprising, as the middle level child wants to know and better understand the world he lives in. Real-life scenarios are highly engaging for students at this age level. The students were also more willing to participate after the whole group instruction time was over, finding with small groups that it was easier for them to determine if their peers were or were not also struggling with new concepts. They were less afraid to take risks and ask questions in the smaller group setting. The peer influence and confidence levels of the middle level child play a large role in his or her ability to function in the classroom. When less focus by the whole group is placed on the student, he is more able to freely engage in the materials and take risks involved in learning new concepts.

The goals of the randomization-based curriculum for teaching statistics and probability included focusing students' attention towards the logic of inference in order to better understand real data and to give students exposure to a modern, technology focused technique. The curriculum de-emphasized descriptive statistics and emphasized active learning and analysis. Using this curriculum not only improved students' understanding of the Common Core State Standards for Math in the domain of Statistics and Probability as seen by the 12.75% average improvement score for the students from the pre- to post-test, but it also offered an approach that can be beneficial for all objectives in the Christian middle school mathematics department.

The unit began focused on a Biblical foundation. The first focus recognized God as the Creator and Sustainer of all areas of creation. (Psalm 24:1, John 1:1-3, Hebrews 1:3) In Christ, all things are possible (Philippians 4:13), and having this understanding is crucial in analyzing and applying statistics from one's daily life that might seem impossible. God's Word is the ultimate authority. When studying mathematical concepts and terms that imply something occurs by chance, it is necessary the students have the foundational definitions of those words, based on God's Word. This unit began by defining terms in light of God's Word. Throughout the three-week unit, the students were reminded of the definition of random as being, "not determined or influenced by man." Outcomes and results in the students' lives may seem random, but God's Word reminds them that nothing happens outside His Will.

Being created in God's Image, and bearing His qualities, the students had a God-given desire to participate in real activities that had real meaning and purpose. The GAISE Report suggestions of using real-life data and the examples given in Tintle's *Introduction to Statistical Investigations* support this God-given trait of the middle school students. Digging deeper, as the students made inferences from the statistics and scenarios given, they were being led to look at the whole context, the whole picture, before making a decision or a judgment. Today's culture suggests that people have the tools and resources to have everything they want at their fingertips, instantly. However, God's timing is not the world's timing. God's ways are not the ways of the world. God takes the time to look at the heart. Man is quick to judge. By training the students to analyze the full picture, to make inferences and ask questions like "does this make sense?" or "what else could be causing this?" the students are encouraged to slow down and think! This goal of statistical literacy has great implications for many career options for students in statistics but also encourages students to show integrity and care in whatever God calls them to.

It is very difficult as a teacher to watch students struggle, and as our culture continues to speed up, it becomes even more frustrating to watch students wrestle with solving problems. However, in teaching statistical literacy, educators have the opportunity to show students that there is much more to be learned from analyzing the full picture than the right answer or the wrong answer. With real-life examples that go beyond a quick response for the students, it was found that the students took a greater ownership of understanding the process rather than having the right solution. With real-life data where the students knew the participants, the students were also more likely to analyze what or who was causing the difference in averages, and in one case this led to seeing the impact of an outlier on the full set of data. That one example will hopefully encourage students to question each statistic presented to them in the future.

Having a unit that was clearly divided into a week of theory followed by two weeks of real-life applied math, made evident the impact of real-life examples. The researcher believed that the students would need the tools before they could participate in applying the chance models to making inferences about the statistics, but instead, the students were more frustrated until they had a reason to learn and use the tools. The impact of real-life examples on the engagement level of students was tremendous. The motivation level was instantly increased. Students showed similar improvements when allowed to work with groups. Their questions and abilities became much more clear to themselves as students as well as to the teacher. Barriers were broken down in understanding and engaging the social nature of the students.

Summary

Adopting the Common Core State Standards for Mathematics is required of all teachers in the United States. Before a seventh grade mathematics teacher can adopt the Common Core State Standards for Mathematics in the domain of Statistics and Probability, questions concerning the curriculum available, the best methods of instruction, and the nature of the seventh grade student must be addressed. In evaluating the presented standards, the suggested guidelines for instruction, the cognitive abilities of seventh grade students, and an undergraduate introductory level statistics curriculum, it was determined that using a randomization-based approach to teaching statistical inference and the examples presented in *Introduction to Statistical Investigations,* an undergraduate introductory level statistics curriculum, would effectively teach the standards for seventh grade probability and statistics.

The researcher developed and implemented a three-week unit on statistics and probability. A pre-test was given to twenty-five seventh and eighth grade students at a small Christian school in eastern Iowa. From there, the unit began with setting a Biblical framework for the study of probability and statistics in which God’s sovereignty over random models was studied and discussed. Next, one week was spent learning the tools of calculating simple and compound probabilities. The students learned definitions for key terms in statistics and probability including probability, simulation, tree diagram, compound probability, variability, sample, population, biased sample, unbiased sample, and random sampling. They learned how to calculate basic and compound probabilities through hands-on activities involving flipping a coin, drawing a card, and choosing colored candies. Coin-tossing apps were used to simulate multiple events quickly and to encourage students to use technology to calculate probabilities.

In the second and third weeks, students applied the randomization methods to real-life scenarios in order to test statistical significance. For example, when the result of a real-life study has a 50% chance of occurring, flipping a coin can simulate that same event, because each result on a coin has a 50% chance of occurring. The students were encouraged to compare the results of random events, to the results of real-life events, to determine if the real-life results might simply be a result of chance. (Outcomes not determined by man.) The students used a 3S strategy, *statistic, simulate, strength,* to identify the statistic, repeat the statistic (through simulation), and discus the strength of the statistic. In combination with a four step approach to studying statistics: 1) Formulate questions, 2) Collect data, 3) Analyze the data (this is where the 3S's are applied), and 4)Interpret the results, the students developed statistical literacy and gained a deeper understanding of the Common Core Standards for probability and statistics.

At the end of the unit, the pre-test was given to the students as a post-test, and the results were compared. Overall, the students performed better on sixteen of seventeen questions from the pre-test to the post-test. Starting with an average of 55% and ending with an average of 67.75%, the overall average of the post-test was 12.75% better than the pre-test scores.

By assessing the level of engagement of the seventh grade students and the level of understanding for the probability and statistics objectives, the researcher determined that the randomization approach to statistical inference presented in Tintle's *Introduction to Statistical Investigations* and the recommendations given by the GAISE report were very effective in teaching the Common Core State Standards for Math in the area of Statistics and Probability for seventh grade math students.

Conclusion

The Common Core State Standards for Mathematics in the area of Statistics and Probability must be adopted. With little pedagogical support, curriculums not yet written, and students not prepared for the new standards, teachers are facing many challenges. Through evaluating the standards, the GAISE report guidelines, and Cobb and Tintle's focus on teaching statistical inference to statistics students, the researcher developed a three-week unit teaching statistics and probability standards to seventh grade students. The researcher implemented this unit in her seventh and eighth grade math classes and found that teaching inference to the students and using the real-life examples from *Introduction to Statistical Investigations* promoted the teaching of the Common Core Standards for probability and statistics as well as a deeper understanding of a Biblical worldview and the responsibility the students have as stewards of God's Creation.

Implications

An inference-based approach to teaching statistics and probability has implications for not only the seventh grade statistics course, but also for the seventh grade mathematics classroom and middle school classroom in general. To begin with the implications for teaching seventh grade statistics, using an inference-based approach encouraged the students to go through the steps of each problem in a way that had the students analyzing and questioning results. From the very beginning of each problem, students were asked, "What are possible explanations?" requiring the students to slow down, reflect on the data presented, and think before simply using the algorithm presented at the top of the page. As the students made inferences, they were asked several questions. What does the statistic suggest? Is the result significant? Does the result make sense? These questions helped foster students who look beyond the number given as the "right answer" to determine what that right answer was suggesting. These questions could be effectively asked in any strand of mathematics and likely produce similar results.

Using chance models to evaluate real-life scenarios gave students the opportunity to not only be hands on in calculating probabilities, but to also use technology in a very practical and efficient way. The real-life scenarios provided purpose and meaning. The chance models provided further data and hands-on activities for computation as well as deeper engagement with the standards. Real-life scenarios gave the students a higher motivational level for participating in the assignments. They wanted to know the significance of the results of real experiments. Real-life scenarios can be used in any strand of mathematics and likely produce similar results.

For one specific scenario, students were asked to evaluate data collected from the students themselves and their siblings and parents. The students asked how many text messages each person sent in a day. One student's sibling had sent 400 text messages that day. This number was a clear outlier from the rest of the data collected. Because the students knew that sibling well and knew that number, they could easily explain its affect on the data set's average. When future averages are skewed, the students will have a deeper foundation of the effects of an outlier because of their personal connection to this outlier. They will be more likely to ask themselves if there are any outliers affecting the data. This knowledge of outliers can be applied in reading statistics in any area of their daily lives.

Initially, when evaluating the Common Core State Standards for seventh grade statistics, the researcher thought it would be most beneficial to teach standards 7.SP.5 – 7.SP.8 before teaching standards 7.SP.1 – 7.SP. 4 in order to provide the students with the tools of statistics and probability before introducing them to application scenarios in which the chance models could help students make inferences about the strength of the real-life statistics. However, it was observed that the students were less engaged and more frustrated by the chance models when they were performing simulations without purpose or reason. The concepts were too abstract and seemingly not practical. Students were also asked to design simulations for events that basically were simulations as well. This concept became more confusing than what it really should be at the seventh grade level. When teaching these lessons in the future, ideally the tools presented in Lessons 2-4 could be taught in previous years and alongside Lessons 5-9 as opposed to being introductory lessons for this unit. It seemed that without the purpose, the energy of the new unit was lost and not regained until Lesson 5. It is believed that the unit could be even more beneficial to the students if Lessons 2-4 were combined with Lessons 5-8, requiring more time for each lesson or more days spent on each lesson in exchange for more engagement of the students and overall, greater purpose.

Taking the approach of starting in whole group instruction, moving on to small groups, and following it up with independent work was well received by the students. The whole group instruction time became shorter each day, as the students became more eager to work together to analyze the scenarios presented. With the small group size, students were held more accountable to participate in class, and the researcher could better determine how well the students understood the concepts presented. Once again, this approach does not need to be limited to the statistics classroom.

Lastly, the research presented does imply that an inference-based approach to teaching statistics and probability is a beneficial approach. The students were engaged throughout the unit and showed significant improvement in test scores from the beginning of the unit to the end. Showing improvement in all questions except one, the results of the students display evidence that the Common Core State Standards for Mathematics in the area of statistics and probability were effectively taught. The lessons with further revision can continue to be used and developed.

Limitations

While the unit written for this research provides a three-week structure for seventh grade students, a comprehensive curriculum has yet to be published. In order to support the objectives in seventh grade, basic objectives for teaching statistics and probability need to be covered beginning in earlier grades and continuing through high school. This unit is a very small part of the full scope. The GAISE report provides a framework for the varying levels of statistics students from a beginning awareness of statistical questions to a deeper level in which students can look beyond the data given. The full educational program, K-12, needs to develop a curriculum that recognizes the developmental process of statistical education. The GAISE report separates the developmental process into three levels, Level A, B, and C, to offer suggestions for implementation. One limitation of the unit presented in this specific research is that students at this age may be at any one of three main levels. Because of the small class size and relatively low level of diversity in students, the unit worked well with this group, but in a more diverse setting, the results may differ.

Another limitation this research presents is the lack of resources to support this method. The teacher was not trained in statistics, did not have a seventh grade statistics text, and because of the newness of the unit did not have ready access to a surplus of examples for further practice. Developing a new unit to cover new objectives requires time and resources that have yet to be created. While the students thrived on real-life examples to investigate, the teacher struggled to continue to find meaningful examples as quickly as other math topics allow.

Because this was the first year of an extensive study in statistics and probability, students did not have the prior knowledge needed as well. Some of the frustration felt in the implementation this year will be eliminated in future years as the prerequisites are covered in earlier grades.

Throughout the three-week unit, the time restraint of each lesson was evident. There was never enough time in a forty-two minute block to effectively dive into each concept. The three weeks devoted to statistics were also not enough. Because statistics are prevalent in all areas of study, it would be recommended to review the inference-based approach and 3S Strategy regularly throughout the school year. Perhaps in correlation with current events, teachers could choose one statistic each week from the newspaper to analyze. This would provide a more thematic approach to teaching statistics that encourages students to see that statistics and math objectives are not only practical in math class. There is some limitation here for larger schools as middle schools are usually divided into discipline specific teaching responsibilities. In schools where this is the case, there would be an increased responsibility for the math teacher to be educating the reading, social studies, and science teachers to also be encouraging statistical literacy amongst the students. How wonderful it would be if all teachers could be asking the students to apply the 3S Strategy each time a statistic is presented in class materials!

In conclusion, statistics education in seventh grade is just a start to many possible reformations in statistics education K-12 as well as in math education. The new objectives in the

Common Core State Standards and the emphasis on statistical literacy supported by the resources of the GAISE Report and Tintle and colleague's *Introduction to Statistical Investigations* open a door to a highly effective and beneficial approach to not only statistics education but also mathematics education as a whole. With further revision, this approach can continue to emphasize teaching children to develop statistical reasoning alongside teaching children to think, to analyze, to question, and to infer in all areas of life.

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APPENDIX A

Common Core State Standards for Mathematical Practice

MP1) Make sense of problems and persevere in solving them.

MP2) Reason abstractly and quantitatively.

MP3) Construct viable arguments and critique the reasoning of others.

MP4) Model with mathematics.

MP5) Use appropriate tools strategically.

MP6) Attend to precision.

MP7) Look for and make use of structure.

MP8) Look for and express regularity in repeated reasoning

Common Core State Standards for Mathematical Content – 7^{th} Grade
Statistics and Probability:

Use random sampling to draw inferences about a population.

1) Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.

2) Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions. *For example, estimate that a mean word length in a book by randomly sampling words from the*

book; predict the winner of a school election based on randomly sampled survey data. Gauge how far off the estimate or prediction might be.

Draw informal comparative inferences about two populations.

3) Informally assess the degree of visual overlap of two numerical data distributions with similar variabilities, measuring the difference between the centers by expressing it as a multiple of a measure of variability. *For example, the mean height of players on the basketball team is 10 cm greater than the mean height of players on the soccer team, about twice the variability (mean absolute deviation) on either team; on a dot plot, the separation between the two distributions of heights is noticeable.*

4) Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations. *For example, decide whether the words in a chapter of a seventh-grade science book are generally longer than the words in a chapter of a fourth-grade science book.*

Investigate chance processes and develop, use, and evaluate probability models.

5) Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around ½ indicates an event that is neither unlikely, nor likely, and a probability near 1 indicates a likely event.

6) Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability. *For example, when rolling a number cube 600 times, predict that a 3 or 6 would be rolled roughly 200 times, but probably not exactly 200 times.*

7) Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.

a) Develop a uniform probability model by assigning equal probability to all outcomes, and use the model to determine probabilities of all events. *For example, if a student is selected at random from a class, find the probability that Jane will be selected and the probability that a girl will be selected.*

b) Develop a probability model (which may not be uniform) by observing frequencies in data generated from a chance process. *For example, find the approximate probability that a spinning penny will land heads up or that a tossed paper cup will land open-end down. Do the outcomes for the spinning penny appear to be equally likely based on the observed frequencies?*

8) Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation.

a) Understand that, just as with simple events, the probability of a compound event is the fraction of outcomes in the sample space for which the compound event occurs.

b) Represent sample spaces for compound events using methods such as organized lists, tables and tree diagrams. For an event described in everyday language (e.g., "rolling double sixes"), identify the outcomes in the sample space which composes the event.

c) Design and use a simulation to generate frequencies for compound events. *For example, use random digits as a simulation tool to approximate the answer to the question: If 40% of donors have type A blood, what is the probability that it will take at least 4 donors to find one with type A blood?*

APPENDIX B

Seventh Grade Statistics and Probability Unit Pre- and Post-Test

The following test was created using the Comprehensive Assessment of Outcomes for a first course in Statistics (CAOS) and the Common Core State Standards for Mathematics Statistics and Probability for Seventh Grade Students

1. A member of your school's basketball team has an 83% free throw shooting percentage. He is shooting two free throws to tie the score of the championship game. What is the likelihood he makes his free throws? (7.SP.C.5)

   a. Not possible

   b. Not likely

   c. Likely

   d. Certain

2. Seven out of every 60 manufactured mechanical pencils have a defect. Out of a batch of 24,000 mechanical pencils, how many do you expect will have a defect? (7.SP.C.6)

   a. 28 pencils

   b. 240 pencils

   c. 2800 pencils

   d. 67 pencils

3. Marcy, Karen, Phil, and Doug are in the running to win a new calculator. If all their names are placed in a hat and one is pulled out randomly, what is the probability that Doug's name will be picked? (7.SP.C.7a)

   a. 25%

   b. 1/5

   c. 75%

   d. 1/3

4. A friend is trying to convince you that spinning a coin on its edge is more likely to land tails than heads. In 14 spins, he obtains 12 tails. Are you convinced?

   a. No, he probably just got lucky

   b. This proves that a spun coin is more likely to land on tails

   c. There is some but weak evidence that spun coin is more likely to land on tails

   d. There is strong evidence that a spun coin is more likely to land on tails

5. You roll a standard six-sided die and spin and spinner with two blue spaces and two red spaces. Which of the following is the sample space of possible results? (7.SP.C.8b)

   a. Blue 1, Blue 2, Blue 3, Blue 4, Blue 5, Blue 6, Red 1, Red 2, Red 3, Red 4, Red 5, Red 6

   b. Blue 6, Blue, 6, Red 6, Red 6

   c. Red 1, Red 2, Red, 3, Blue 1, Blue 2, Blue 3

   d. Blue Red, Blue Red, Blue Red, Blue Red, Blue Red, Blue Red

6. Based on the sample space chosen for #5, what is the probability of rolling a 6 and landing on a blue space? (7.SP.C.8a)

   a. 1/10

   b. 1/8

   c. 1/12

   d. 1/24

7. A certain manufacturer claims that they produce 50% brown candies. Sam plans to buy a large family size bag of these candies and Kerry plans to buy a small fun size bag. Which bag is more likely to have more than 70% brown candies? (7.SP.B.4)(CAOS #16)

   a. Sam, because there are more candies, so his bag can have more brown candies.

   b. Sam, because there is more variability in the proportion of browns among larger samples.

   c. Kerry, because there is more variability in the proportion of browns among smaller samples.

   d. Kerry, because most small bags will have more than 50% brown candies.

   e. Both have the same chance because they are both random samples.

8. Imagine you have a barrel that contains thousands of candies with several different colors. We know that the manufacture produces 35% yellow candies. Five students each take a random sample of 20 candies, one at a time, and record the percentage of yellow candies in their sample. Which sequence below is the most plausible for the percent of yellow candies obtained in these five samples? (7.SP.A.2)(CAOS #17)

   a. 30%, 35%, 15%, 40%, 50%

   b. 35%, 35%, 35%, 35%, 35%

   c. 5%, 60%, 10%, 50%, 95%

   d. Any of the above.

9. Jean lives about 10 miles from the college where she plans to attend a 10-week summer class. There are two main routes she can take to the school, one through the city and one through the countryside. The city route is shorter in miles, but has more stoplights. The country route is longer in miles, but has only a few stop signs and stoplights. Jean sets up a randomized experiment where each day she tosses a coin to decide which route to take that day. She records the following data for 5 days of travel on each route.

   Country Route - 17, 15, 17, 16, 18
   City Route - 18, 13, 20, 10, 16

   It is important to Jean to arrive on time for her classes, but she does not want to arrive too early because that would increase her parking fees. Based on the data gathered, which route would you advise her to choose? (7.SP.B.4)(CAOS #18)

   a. The Country Route, because the times are consistently between 15 and 18 minutes.

   b. The City Route, because she can get there in 10 minutes on a good day and the average time is less than for the Country Route.

   c. Because the times on the two routes have so much overlap, neither route is better than the other. She might as well flip a coin.

10. A student participates in a Coke versus Pepsi taste test. She correctly identifies which soda is which four times out of six tries. She claims that this proves that she can reliably tell the difference between the two soft drinks. You have studied statistics and you want to determine the probability of anyone getting at least four right out of six tries just by chance alone. Which of the following would provide an accurate estimate of that probability? (7.SP.A.2)(CAOS #37)

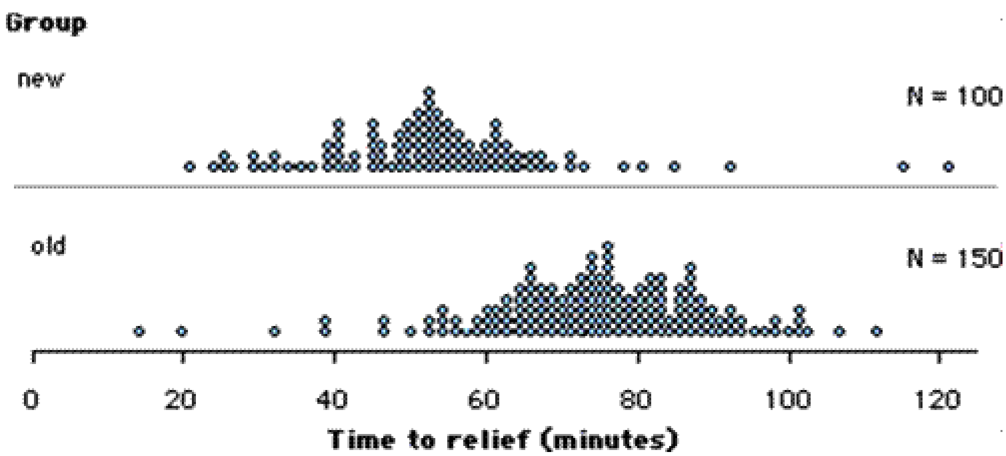
    a. Have the student repeat this experiment many times and calculate the percentage time she correctly distinguishes between the brands.

    b. Simulate this on the computer with a 50% chance of guessing the correct soft drink on each try and calculate the percent of times there are four or more correct guesses out of six trials.

    c. Repeat this experiment with a very large sample of people and calculate the percentage of people who make four correct guesses out of six tries.

    d. All of the methods listed above would provide an accurate estimate of the probability.

Items 11 to 13 refer to the following situation: (7.SP.B.3)(CAOS #11-13)
A drug company developed a new formula for their headache medication. To test the effectiveness of this new formula, 250 people were randomly selected from a larger population of patients with headaches. 100 of these people were randomly assigned to receive the new formula medication when they had a headache, and the other 150 people received the old formula medication. The time it took, in minutes, for each patient to no longer have a headache was recorded. The results from both of these clinical trials are shown below. Items 11, 12, and 13 present statements made by three different statistics students. For each statement, indicate whether you think the student's conclusion is valid.



11. The old formula works better. Two people who took the old formula felt relief in less than 20 minutes, compared to none who took the new formula. Also, the worst result - near 120 minutes - was with the new formula.

    a. Valid.

    b. Not valid.

12. The average time for the new formula to relieve a headache is lower than the average time for the old formula. I would conclude that people taking the new formula will tend to feel relief about 20 minutes sooner than those taking the old formula.

    a. Valid.

    b. Not valid.

13. I would not conclude anything from these data. The number of patients in the two groups is not the same so there is no fair way to compare the two formulas.

    a. Valid.

    b. Not valid.

14. Paul has a 10 question true and false quiz in history over material he has not learned. He wants to determine the likelihood of guessing correctly for his test and scoring 100%. Which simulation should Paul repeatedly use? (7.SP.A.2)

a. Tossing a coin

b. Rolling a six-sided standard number cube

c. Spinning a spinner with 4 congruent sections

d. Drawing chips from a bag with 10 different colored chips.

15. Researchers gathered 30 individuals suffering from mild to moderate depression and brought them to an island. At the island, the 30 individuals were randomly divided into two treatment groups. One group received therapy in which they swam with dolphins. The other group did not swim with dolphins. The results were as follows:

	Dolphin Therapy	No Dolphin Therapy	Total
Showed significant improvement	10	3	13
Did not show significant improvement	5	12	17
Total	15	15	30

To determine whether these study results provide convincing evidence that swimming with dolphins is more beneficial than simply going to an island for mild to moderately depressed subjects, a statistician can use simulations. If dolphin therapy is no more effective than having no dolphin therapy, then we will have 13 improvers and 17 non-improvers regardless of which group they were assigned. Which of the following simulations should we use to determine if swimming with dolphins is or is not more beneficial? (7.SP.C.8c)

a. Flip a coin 30 times; heads means improvement, tails means no improvement.

b. Use 13 red cards to represent those who had improvement, 17 black cards for no improvement. Shuffle the cards and redistribute them into two groups: one representing the dolphin therapy group, the other representing no dolphin therapy.

c. Flip a penny to represent the dolphin therapy group 15 times; heads means improvement, tails means no improvement. Repeat with a dime for the no dolphin therapy group.

d. Use 15 red cards to represent those who did improve. Use 15 black cards to represent those who did not improve. Shuffle the cards and redistribute them into two groups: one representing the dolphin therapy group, the other representing no dolphin therapy.

16. You survey every fifth student leaving basketball practice. Of those surveyed, 95% support a proposal to buy new bleachers for the gym. Is this an appropriate sample to support purchasing new bleachers? (7.SP.A.1)

    a. Yes, 95% of random basketball players supported the purchase of new bleachers. That 95% was randomly selected forming an appropriate sample.

    b. No, although randomly selected, the basketball players are not representative of the whole student body.

17. You want to find out whether students believe the extra funds from a recent fundraiser should be spent on the music program of your school. Which of the following ways is the best way to interview a sample of the student body population? (7.SP.A.1)

    a. Interview every tenth teenager you see at the mall.

    b. Interview the students in band.

    c. Interview every tenth student leaving a school assembly.